Supporting Information

Effect of a Magnetic Field on the Activity of Superoxide Dismutase Studied at the Enzyme Level

Sangwoo Yoon,[a,b] Seung-Cheol Chang,[a] Gregory F. Payne,[c] Seunghun Lee,[d] Kwangseuk Kyhm,[a] Sung-Gyu Park,[b] and Mijeong Kang[a,e]*

[a] Department of Cogno-Mechatronics Engineering, Pusan National University (PNU), Busan 46241, Republic of Korea.

[b] Advanced Bio and Healthcare Materials Research Divison, Korea Institute of Materials Science (KIMS), Changwon 51508, Republic of Korea

[c] Institute for Bioscience and Biotechnology Research, University of Maryland, College Park, Maryland 20742, United States

[d] Department of Physics, Pukyong National University, Busan 48513, Republic of Korea
[e] Crystal Bank Research Institute, Pusan National University, Busan 46241, Republic of Korea

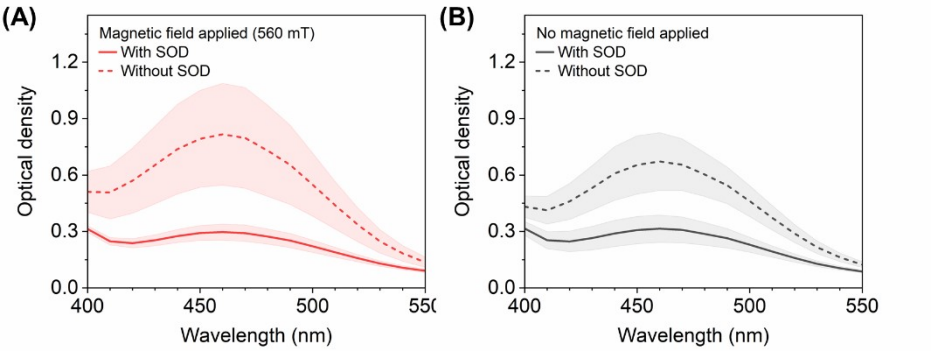

Figure S1. Effect of magnetic field on the activity of superoxide dismutase (SOD). Absorption spectra of solutions containing xanthine, xanthine oxidase (XOD), and water-soluble tetrazolium 8 (WST-8) (dashed lines) and of solutions additionally containing SOD (solid lines), recorded in the presence (A) and the absence (B) of a magnetic field (flux density: 560 mT). All spectra were obtained 10 minutes after the addition of XOD to the solution containing xanthine and WST-8 with or without SOD. Lines and shaded areas denote average and standard deviation, respectively (N = 10 per group). In the presence of a magnetic field, the suppression of the WST-8 formazan absorption peak intensity by SOD reached 63.6%, whereas in the absence of a magnetic field, a weaker suppression of 56.1%

was observed.

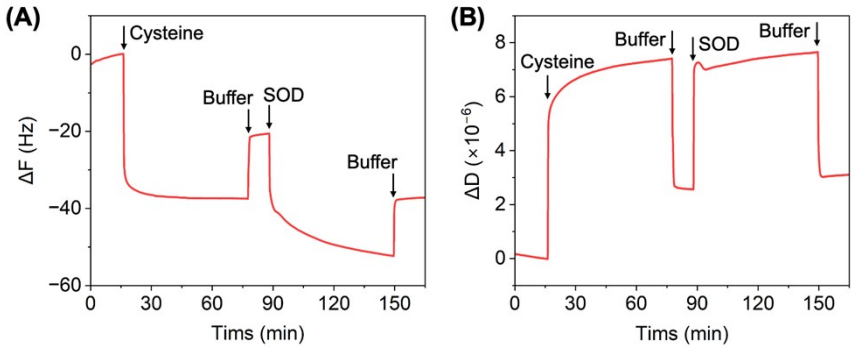

Figure S2. Behavior of superoxide dismutase (SOD) adsorption on a cysteine-coated Au surface observed from quartz crystal microbalance with dissipation monitoring (QCM-D) measurement. Shifts in frequency (A) and dissipation factor (B) over time were observed while the Au-coated quartz crystal was sequentially exposed to 10 mM cysteine solution, blank buffer, 10 μM SOD solution, and blank buffer.

To verify the adsorption of superoxide dismutase (SOD) on the cysteine-modified Au electrode, quartz crystal microbalance with dissipation monitoring (QCM-D) measurements were performed using an Au-coated quartz crystal as a model surface for the Au working electrode. The crystal was sequentially exposed to 10 mM cysteine solution, blank buffer, 10 μM SOD solution, and buffer. As shown in Figure S2, cysteine injection caused a rapid decrease in the frequency shift (Δf), indicating an increase in acoustic mass due to cysteine adsorption on the Au-coated quartz crystal. The simultaneous increase in the dissipation factor shift (ΔD) suggests that the surface modification was accompanied by changes in the interfacial hydration environment and/or weakly coupled adsorbed species. During the subsequent rinsing step with buffer, both Δf and ΔD partially recovered, indicating the removal of loosely associated species and solution-exchange-related contributions. The residual negative Δf after rinsing confirmed the formation of a stable cysteine-modified Au surface. When SOD was introduced onto this rinsed cysteine-modified Au surface, Δf decreased further, demonstrating the adsorption of SOD. This decrease was accompanied by an increase in ΔD on the order of 10^{-6}, suggesting changes in the interfacial state of the adsorbed SOD layer rather than simple rigid mass loading alone. After the final rinsing step, both signals partially recovered, which is consistent with the removal of weakly bound SOD species. However, Δf remained more negative than the baseline before SOD injection, confirming that a portion of SOD was retained on the cysteine-modified Au surface after rinsing.